우리원이 주최한 국제 워크숍

"연구실의 안전 및 환경 관리를 위한 국제워크숍"이 2007년 11월 23일 오후 1시에 서울대학교 박물관 강당에서 전국 각 기관의 실험실 안전 담당자 150여 명이 참석한 가운데 성대히 개최되었다.

이번 워크숍은 이웃 나라인 일본과 대만에서는 실험실 안전 및 폐기물 관리를 어떠한 제도와 방식으로 관리하고 있는지 알아보기 위해 현지의 전문가 두 분을 모셔 실질적이고 현장감 있는 강의를 들을 수 있었다.

또, 국내 연사 두 분을 모셔 실험실 안전현황과 실험실 폐기물 처리비용 유료화에 대한 강의를 들을 수 있었다. 강의가 끝날 때마다 많은 질문이 쏟아져 실험실 안전관리의 높은 관심을 알 수 있었다.

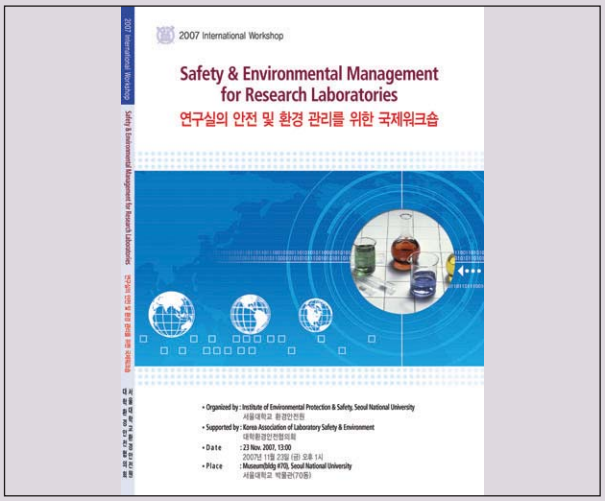
강사 및 강의 주제에 대하여 소개한다면 다음과 같다.

"국내외 연구실 안전현황 및 중장기 발전 방향"
박교식 (한국가스안전공사 가스안전연구개발원 시설연구실장)

"일본에서의 연구실 안전환경 관리"
Kazuo Yamamoto (동경대학 환경안전센터장)

"실험 폐기물 처리비용의 유료화"
한현정 (서울대학교 환경안전원)

"대만의 고등교육기관에서의 실험실 안전 및 폐기물 관리"
Chih-Chieh Chen (대만대학 직업의학 및 산업보건원 원장)



국제 워크숍 발표자료

대만대학Chih-Chieh Chen 교수

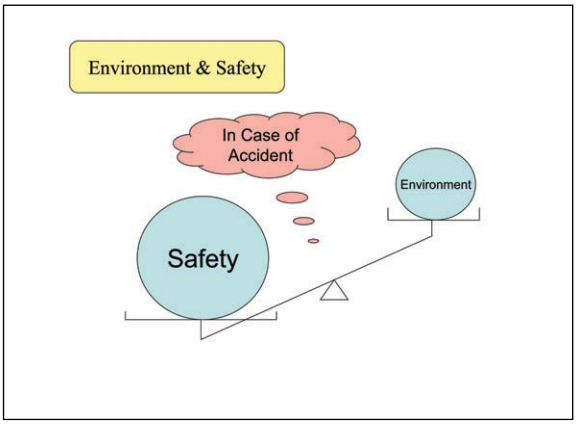
워크숍 참석자들

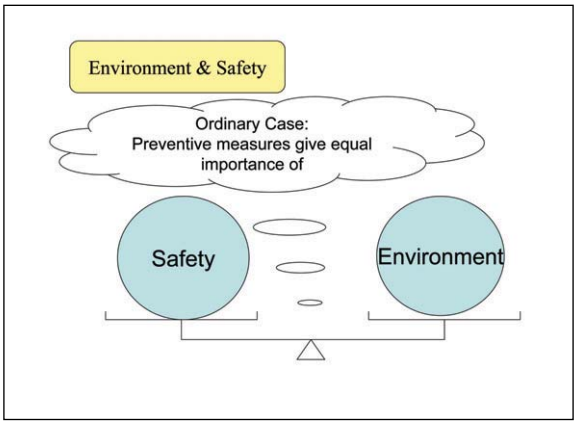
동경대학 Kazuo Yamamoto 교수

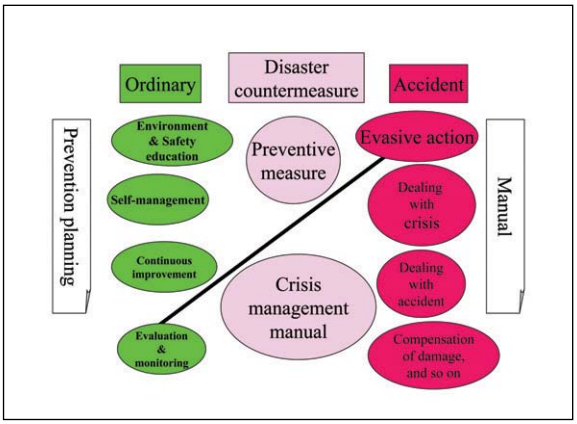
다음은 Kazuo Yamamoto 교수님과 Chih-Chieh Chen 교수님의 강의 자료를 「국제 워크숍 발표자료집」에서 발췌하여 수록하였다.

Safety & Environmental Management for Research Laboratory in Japan - A Case of UT -

Kazuo Yamamoto (동경대학)







Example of Laboratory Safety Education

Environment and Safety Course
I. Safety in the Laboratory

Environmental Science Center
The University of Tokyo

Example of Laboratory Safety Education

Outline

1. Hazardous chemicals
   Fire-related, toxicity, high-pressure gas
2. In case of accident, …
3. Important rules in the laboratory

Example of Laboratory Safety Education

1. Hazardous chemicals

- Fire-related
- Toxicity
- High pressure (physical hazard)
- Radioactivity
- Biohazard (*see Chapter 9*) etc.

To know the hazard, obtain and study the **MSDS** of each chemical.

Example of Laboratory Safety Education

MSDS?

- Material Safety Data Sheet lists:

  -Name of substance and purity
  -Procedures to handle/preserve
  -Physical/chemical properties
  -Stability/reactivity
  -Toxicity
  -Procedures to discard/transport
  -First-aid, etc.

- Study before handling the chemical.
- Ask the vendor to provide MSDS.

Example of Laboratory Safety Education

UTCRIS (UT Chemical Registration Information System)

https://utcris.adm.u-tokyo.ac.jp/CRIS_v1_0/index.aspx

- For management of chemicals in your lab.
- MSDS can be downloaded.

Japanese law requires that:
1) Poisonous/deleterious chemicals are stored in lockable racks, and
2) Their amounts and usage are logged.

Example of Laboratory Safety Education

a) Corrosives

- Irritate or hurt skin
- Example: acid, alkali, etc.
- Precautions

  -**Wear appropriate protective equipments.**
  goggles, gloves, face shield etc.

- In case of spill on the skin,
  -Flush with running water for >15 min.
  -Never try to neutralize!
  -Consult a doctor.

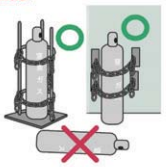
Example of Laboratory Safety Education

2. In case of accident… (1) Injury

- Apply first-aid
- Call hospital, and go (with a companion).
  Tell your name and department, and explain the injury and first-aid.
  (In Hongo)
  -*Hoken* Center: ext. 22575
  -Univ. Hospital (open 24h): ext. **34100**
  Ask your instructor and confirm where to call.
- If necessary, call 119 (Campus Security) and ask for an ambulance.

1-(3) High-pressure gases ~Gas cylinders

- Precautions
  -Use an appropriate regulator for each gas.
  -Remove the regulator when transporting cylinder.
  -Secure the cylinder **with two bands**.
  Use of a stand is desirable.
- Color-code (Japanese rule)
  Oxygen: Black
  Hydrogen: Red
  Chlorine: Yellow
  Carbon dioxide: Green
  Acetylene: Brown
  Ammonia: White
  Others: Gray



Example of Laboratory Safety Education

2. In case of accident… (2) Fire

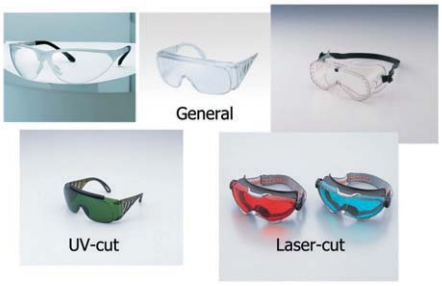
- Make yourself safe against fire.
  (Confirm the evacuation route.)
- Let other people know (SHOUT!).
- Use an extinguisher, if possible.
  (*Don't try too hard!*)
- Evacuate.
- Call fire station or Campus Security (119).
  Ask your instructor and confirm where to call.

Example of Laboratory Safety Education

3. Rules in the laboratory (1) Before experiment

- Plan your experiment in detail.
  -List all the chemicals you will use. (Rxn products also).
  -Obtain and study the **MSDS** of the chemicals.
  -Consider possible reactions & potential dangers.
  Haz. Chem./Biohazard/Heat/Cryogenic/Electricity/Laser/Step Hazard etc.
- Prepare appropriate protective equipments.
  -Goggles ← **Wear Always in the Lab!!**
  -Gloves, respirator, face shield, etc.
- Confirm the location of fire extinguishers.

Protective equipments



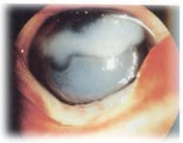
Protective equipments

Protective equipments

Protective equipments

If you do not wear…

Palm damaged by acrylamide



Eyeball (cornea) damaged by sodium hydroxide

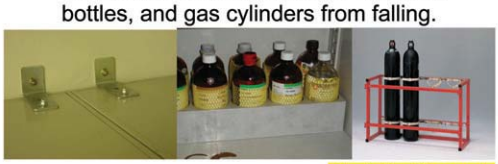
3. Rules in the laboratory (2) During experiment

- Wear protective equipments.
- Treat chemicals under a fume hood.
- Do not work alone at night.
- If you are absent-minded, refrain from experiment.

Sick, tired, sleepy, in a hurry, etc.

Preparation for Earthquakes

- Secure the apparatus, racks, chemical bottles, and gas cylinders from falling.



The stand must be secured on the wall or floor.

University & Environment

Environment

anthropogenic sphere

University

neighbor

Professors & stuffs	7,332
Undergraduate students	14,601
Graduate students	14,171
Total	36,104

(as of May 1, 2007)

UT is a town!

ecosystem/ nature

ommunity/ ociety

Brief History of Environmental Management, UT

- 1975 Environment & Safety Center was founded
- 1977 Collection of Hg-contained wastes such as fluorescent lump was commenced
- 1978 ESC has started collection of lab-wastes and their treatment
- 1979~81 Countermeasures for Hg control in wastewater
- 1984 Provisional UT regulation on PCB storage
- 1986 Groundwater contamination survey

Brief History of Environmental Management, UT

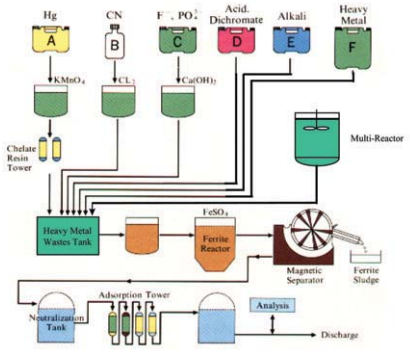
- 1986 Asbestos was detected in lab-air environment.
- 1987 Committee for asbestos was set-up.
- 1989 Infectious waste treatment was discussed.
- 1991 1st ESC Symposium was held.
- 1993 Environmental Science Center was established.
- 1993 Used paper collection and recycle was started in all UT.
- 1993 Environmental ID Course was started for staffs & students.
- 1994 "UT Rubbish Declaration"

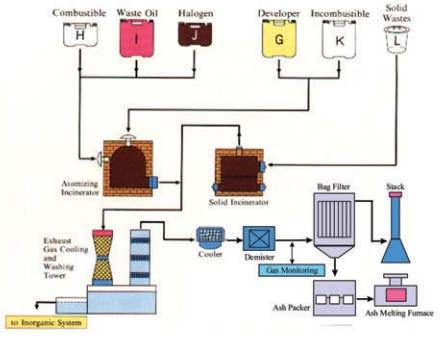
Brief History of Environmental Management, UT

1995 Submission to the President of UT on improvement of water environment and water-cycle in UT campus
1995 Recommendation on equipment of closed-type aspirators in each laboratory for recovery of dichloromethane
1996.1 UT-MIT-ETH joint workshop for AGS(Alliance for Global Sustainability) was held at UT.
1997 Analysis & Treatment for unidentified waste-reagent was started.
1997 Submission to the President on development of municipal solid waste separation & collection system in UT
1997 Submission on setting-up of guidelines on management on toxic, reactive, and explosive substances in all faculties and institutes.

Brief History of Environmental Management, UT

- 1998-2000 Lab-waste plastic recycle as coke-replacement in blast furnace in iron-steel industry
- 1999 Renewal of inorganic & organic laboratory wastes treatment facility (including dioxin control)
- 1999 Full application of the new separation & collection system for municipal solid waste in Hongo-campus.
- 2000 Revise the procedures for inspection on violation of wastewater discharge to sewer.
- 2000 Submission to the President on Environmental Management System in the new campus, Kashiwa.
- 2000 Revise lab-waste plastic separation & collection rule.
- 2000 Measures against formalin wastewater problem
- 2003 Supercritical water oxidation (SCWO) of laboratory waste treatment facility at Kashiwa Campus





（その１）廃液類処理料金

種　別	分類	単位	料金(円)
水銀(無機、有機)系廃液	A	缶(10L)	4,000
シアン系廃液	B	ﾘｯﾄﾙ	480
フッ素化廃液	C	缶(10L)	3,200
クロム(VI)系廃液	D	缶(10L)	4,000
廃酸 廃アルカリ	D E	缶(10L) 缶(10L)	1,600 1,600
一般重金属系廃液	F	缶(18L)	2,880
写真廃液(現像、停止液)	G	缶(18L)	4,600
臭化水素系廃溶剤	H	缶(10L)	2,240
廃油	I	缶(18L)	4,030
ハロゲン系廃溶剤	J	缶(10L)	2,560
水混合有機系廃液	K	缶(18L)	4,600

（その１）廃棄試薬類処理料金

種　別	単位(ml)	料金(円)
一般重金属系(塩類)	500	4,800
一般重金属系(単体)	500	16,000
遊離シアン系	500	8,000
難分解性錯シアン系	500	6,400
フッ素、リン系	500	6,400
リン系(単体)	500	24,000
六クロム酸系	500	4,800
ヒ素系(塩類)	500	8,000
ヒ素系(単体)	500	20,000
発煙硫酸など	500	8,000
アルカリ金属単体	500	16,000
一般有機系	500	4,000
特殊有機系（劇物など、二硫化炭素など）	500	16,000
その他	500	3,200
無機水銀(Hg)	本	3,000
有機水銀(HgY)	本	20,000

注１）廃棄試薬類の最小単位は無機水銀、有機水銀を除き"1g"から計算する。
注２）特殊な廃棄試薬類については、排出者と相談のうえ、個々に処理料金を決定する。

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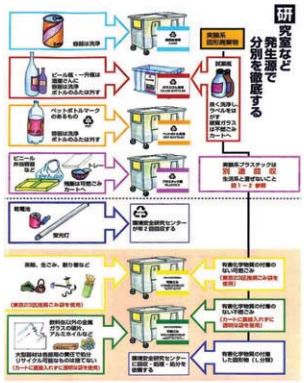
図１－１　本郷キャンパスにおける生活系廃棄物分別収集方法早見表



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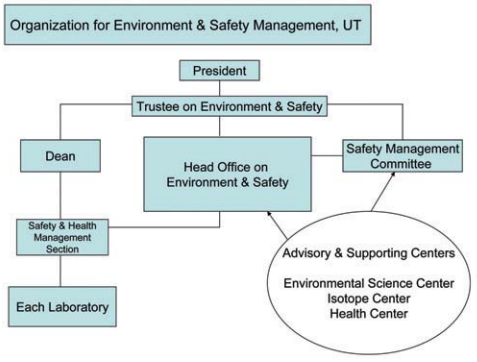
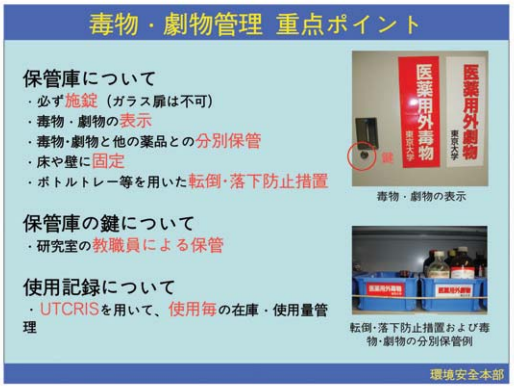
◎柏処理施設の概要

External Pressure

- PRTR (Pollutant Release and Transfer Register) Law (2001)
  ➔ encouraged self-management of chemicals
- National University ➔ Independent Organization as 'Corporation' (2004.4 ～)

Regulatory rule changes!
e.g., Industrial Safety and Health Law





External Pressure

- Environmental Consideration Law/ Law Concerning Promotion of Business Activities with Environment (2005)
  ➔Environment Report (2006～)
- Global Warming countermeasures ➔ University also needs to report on 'greenhouse gas emission' to public (2007～)

UT Environment Report 2006

- Unit Energy Consumption 2.52 GJ/m^2
- Electricity Consumption 294 GWh
- CO_2 Emission 128 kt
- Water Consumption 1.435 Mm^3
- Laboratory waste 208 t
- Infectious waste 767 t
- Municipal waste 1,978 t

On-going JAAAES' projects

- Environmental performance & benchmarking on Environment Report
- Green accounting for university activity
- Management and information systems for chemicals
- Model laboratory for environment & safety education
- R&D for recalcitrant hazardous waste
- Self-management rules for the use of chemicals and equipments in research laboratory

Laboratory Safety &
Waste Management

Chih-Chieh Chen (대만대학)

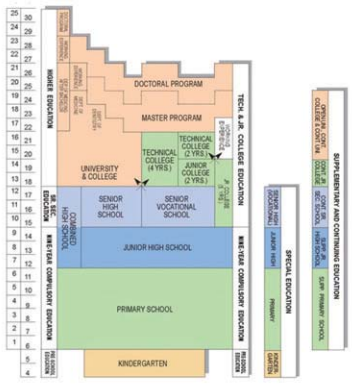
Laboratory Safety & Waste Management

Chih-Chieh Chen, Ph.D., CIH
College of Public Health
National Taiwan University

2003.04~2007.03
Executive Secretary
Environmental Protection Division
Ministry of Education, Taiwan

Outline:

- Laboratory Waste Treatment Plant
  1. Location of ERMRC
  2. Layout
  3. Waste Treatment Facilities
- OSH Education and Training
- National Laboratory Inspection Program

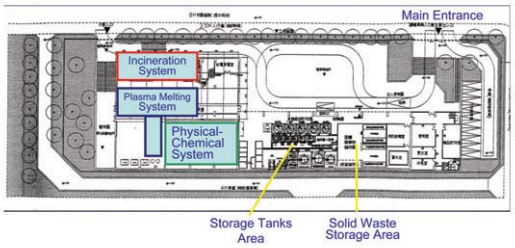


Laboratory Waste Treatment Plant

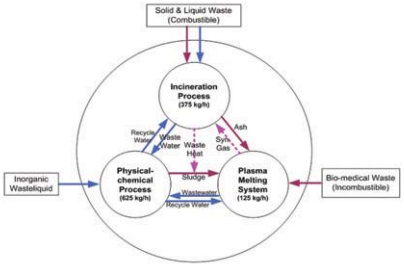
Environmental Resource Management and Research Center
(ERMRC)
National Cheng Kung University

An-Nan Campus, NCKU

Layout – Waste Treatment Plant



Design Concepts



Waste Classification

- Wastes sources
  - Lab. waste from universities and schools in Taiwan
- Waste liquids
  - Organic waste liquids
    with or without chloride
  - Inorganic waste liquids
    cyanide, mercury, acid, base, metals
  - Waste Oils
- Solid Wastes
  - Combustible
  - Incombustible

Objectives

- Wastewater recycling and reuse
- Energy recycling
  - Drying Sludge by waste heat from secondary chamber of Incineration system
  - Synthetic gas from Plasma melting system as fuel
- Dioxin emission is one-fifth of standard
- Decrease the VOC emission by using pipes for waste liquids transporting
- Innovation technology of torch from Russia
- Research functions of treatment facilities

Zero Discharge

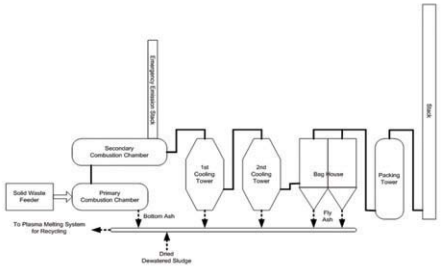
Pumping and Storage Tanks Area

- Platform Scale (15 tons)
- Control Room
- Pumping Set
- Storage Tanks (Organics, Inorganics, Diesel fuel, Liquid Nitrogen)
- Solid Waste Storage Area (Freezer, Storage area)
- Lifters

Pumping Set

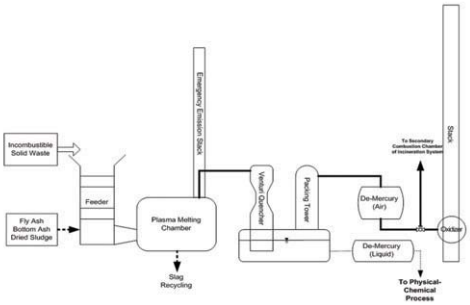
Storage Tanks

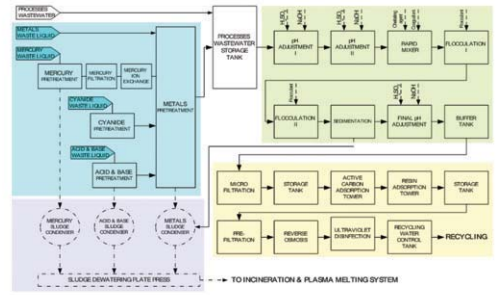
Incineration System – Process




1st
2nd
Cooling Tower
Bag House
2004 11 24


Bag House
Packing Tower


Plasma Melting System – Process
Incombustible Solid Waste
Fly Ash Bottom Ash Dried Sludge
Feeder
Plasma Melting Chamber
Slag Recycling
Emergency Emission Stack
Venturi Demister
Packing Tower
De-Mercury (Air)
De-Mercury (Liquid)
To Physical-Chemical Process
Stack


Physical-chemical Process
MERCURY PRETREATMENT
CYANIDE PRETREATMENT
ACID & BASE PRETREATMENT
METALS PRETREATMENT
RECYCLING
TO INCINERATION & PLASMA MELTING SYSTEM


CSTR Chemical Precipitation Process
Mercury
Cyanide
Acid & Base
Metals
Additives Pumping Set
2004 11 24


4th International Workshop On Microplasmas
2007
Main Menu
Latest News

Operation Cost

MOE subsidizes:

40,000,000 NTD/year, 2005~2014.

MOE covers: treatment cost: 1, 5/6, 4/6,3/6, 2/6, 1/6 for the first 6 years.

Part 2

Occupational Safety and Health

Education and Training

No laboratory: general education
Laboratory: intensive course

INTRODUCTION

- Most undergraduate and graduate students will become members of the workforce.
- Integrating occupational safety and health education into the classroom before employment was proposed to develop positive attitudes toward safety and hygiene.
- Laboratories on campus were asked to comply with the US OSHA regulations since 1990.

Integrated Safety and Health Awareness into Liberal Education (ISHALE)

- Founder: The Ministry of Education in Taiwan
- Mission: a six-year project designed to spread occupational safety and health education throughout all universities.
- Started in 2004
- Scope:
  - The general education of occupational safety and health for all universities and college students.
  - The intensive training courses (5 days, 40 hours) for the new graduate students (who use laboratory)

Course Modules of Occupational Safety and Health

General education

Subject	Subject
Introduction to health and safety	Non-ionizing radiation
Chemical hazards	Safety of machine
Biological hazards	Electricity safety
Hazard communication	Fire and explosion
Ergonomics	First aid
Hazards of computer operations	Respiratory protection
Noise	Personal protective equipment
Ionizing radiation	Waste management of laboratories

Intensive Training Courses for New Graduate Students

- Background
  - Various safety and health hazards exist in university facilities, particularly laboratories and workshops
  - Adequate education and training should be provided to students to assist them in dealing with routine safety issues
- Training courses (40 hours) are hold at various counties in Taiwan during summer break before semester begins (August and September).
- Content: including 16 occupational safety and health subjects and case studies

Course Modules of Training Courses

Specialized education

Issue	Issue
Introduction to health and safety in laboratories	Safety of machine
Chemical hazards	Electricity safety
Hazard communication (3 hrs)	Fire protection
Biological hazards	Principles of ventilation
Ergonomics	Respiratory protection
Hazards of computer operations	Personal protective equipment
Ionizing radiation (3 hrs)	First aid
Non-ionizing radiation	Waste management of laboratories
Noise	Safety laws and regulations of laboratory

Administrative Measures

- **Professional lecturer training program**
  - Lack of lecturers: not enough professional lecturers in all universities.
- To meet the need of lecturers: MOE provides teaching fellowships to fulltime doctoral students from related departments.
- Continuing education: Offer professional developing courses (PDC) during summer and winter breaks
  - Attendee: All fellowship awardees, campus safety and health managers, faculty of related fields

Administrative Measures (continued)

- **Financial support:** Students participate in the program are financially supported by MOE. (45,000 NTD/month)
- **Evaluation and accreditation** is based on the number of courses offered, fraction of students who attended the course and passed the test.

Project Milestone

Development Stage (2003~2004)
- Course module development
- Administrative polices planning

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Initiation Stage (2004~2005)
- Professional lecturer training
- Limited course offering and module revision
- A 5-day intensive training course series

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Progression Stage (2005~present)
- Continuing education
- General education course offering in universities
- Five-day intensive training course
- Program evaluation

Who is in ISHALE?

- **Regional ERCs:**
  - Three regional ERCs were launched in 2004
  - Responsible for
    - Course content and lecturers arrangement for both general education and intensive training courses
    - Continuing education plan
    - Course module development and revision

Who are in ISHALE? (continued)

- **Graduate institutions of safety and health** have participated the professional lecturer training program since 2004.
- **Examination center for safety and health:**
  - Launched in 2006
  - Responsible for
    - Course modules systemization
    - Certification development and implementation (including examination question database)

Results

The occupational health and safety courses in the general education

Number of coursed offered
(Data source: ERC in north region)

Academic year	Schools that offered the course	Total number of available courses	Total enrolled students
(2004~2005)	18	20	1,087
(2005~2006)	47	68	4,336
(2006~2007)	46	119	7,096

Change in Cognition and Attitude toward Safety and Health (by Wu *et al.*, 2006)

- Evaluated the effect of implementing the courses on college students in south Taiwan including cognition and attitude toward safety and health, in 2005~2006.
- Questionnaires were distributed at the beginning and the end of a semester.
  - Intervention group: 353 students receiving the General Education of safety and Health.
  - Control group: 366 students without receiving the General Education of Safety and Health.
- The cognition and attitude toward safety and health of the intervention group were improved significantly.

Further Research for the OHS General Education

- An ongoing study is focused on the long-term effect of training on the change of cognition and attitude.
- The pre-, post- and follow-up tests will be performed on both intervention and control groups from February 2008 to June 2008.
- The questionnaires are under development.

Results of intensive training courses

The intensive training courses for the new graduate students

Results of intensive training courses

- The 5-day intensive training course series were held during summer break since Summer 2005.
  - Each summer, 12 series were held in different counties with 200 participants
  - About 6,000 students have participated up to 2007
- Satisfaction surveys were performed after each 5-day course series
- In 2007, the certification examination was held to evaluate the learning effect.
- What we found:
  - A positive satisfaction with this course
  - Students' knowledge of the OSH improved significantly

Part 3:

Laboratory Safety Inspection and certification

Laboratory Safety Inspection Program

- University researchers often overlook laboratory safety.
- NSC is the major research fund provider to university people. To be funded by NSC, the proposals need to be reviewed. Our goal is to make laboratory safety certification an essential check item in the review process.

Objectives:

- To help promote the awareness of university EHS.
- To establish link with grant proposal review process of National Science Council (NSC).
- Push all universities to set up university level inspection programs.

Methods

- Establish and maintain an internet database of all university laboratories.
- Hold working group meeting and workshop on laboratory safety inspection and certifications (check list).
- Conduct the on-site laboratory inspection.

Results

- Checklist for laboratory inspection
- Annual checklist modification: working group meeting, expert public hearing (EHS personnel, laboratory safety officers).
- Pass rate: 95% for the first 5 years.

Results

First phase：3,483
3★：2,938
2★： 425
1★： 120

Second phase：2,718
3★：2,169
2★： 486
1★： 63

Certificate

Know Safety, No Pain.

No Safety, Know Pain.

Thank you for your attention!